Working with Climate Model Ensembles for the Arab Domain: A Strategy for Dealing with Uncertainty

Phil Graham & Rossby Centre Staff

Swedish Meteorological and Hydrological Institute
An “ensemble” means that we reproduce results many times using variations in how we go about it
Why do we need an ensemble of regional climate projections?
Because different GCMs give different regional climate change signals.
Sampling the sources of uncertainty

Uncertainty in regional climate projection

- Multiple regional models
- Multiple global models
- Emission/Concentration Scenarios
- Multiple downscaling methods
- Internal variability (Multiple realizations)
- Region
Motivating an RCM ensemble

- Future climate changes are uncertain
  → Size and sometimes even sign of changes differs

- An ensemble can illustrate uncertainties

- Regional climate information is needed for impact models and adaptation studies

- Common GCM resolutions do not provide detailed regional climate information
Historical simulations
How good are GCMs in 1961-1990?

Bias w.r.t. CRU TS2.1

Monthly precipitation

Lind & Kjellström, 2008
Ensemble examples from previous Climate scenarios using SRES
Change in mean precipitation (Baltic)

**Summer Precipitation (anomalies wrt 1961-1990)**

> diverse behaviour of different simulations
> the ensemble mean is strongly dominated by one or two simulations
20-year return values of Pmax (wrt 1961-1990)  

Winter

a tendency to more intense precipitation extremes
Impacts applications – using ensembles in hydrological modelling
Analysis of change in 100-year river flows – from hydrological modelling

Kaalasjärvi

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

Munkedal

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

Vänern

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

Viskan

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

Blankaström

30-yr moving window for 100-yr return period
Analysis of change in 100-year river flows – from hydrological modelling

Kaalasjärvi

Reduction of flood magnitude in snow areas

Viskan

Increase of flood magnitude in rain areas
Newest Climate scenarios using RCPs
Temperature trends on a continental scale

2m Temperature anomalies wrt 1970-2000 | 31-yr. mov. mean | (tas) | ANN | Africa (AFR) 20W-50E 40S-35N | land

- RCA4 (CanESM2)
- RCA4 (CNRM-CM5)
- RCA4 (NorESM1-M)
- RCA4 (EC-EARTH)
- RCA4 (MIROC5)
- RCA4 (HadGEM2-ES)
- ENS. MEAN

℃

1980 2000 2020 2040 2060 2080

Year

hist
d rcp26
● rcp45
□ rcp85

8.5
4.5
2.6
RCP 4.5 and 8.5 start diverging somewhere around 2030-2040.
Precipitation Trends on a regional Scale

Precipitation anomalies wrt 1970-2000 | 31-yr. mov. mean | (pr) | JAS |
West Africa/Sahel - North (WA-N) 10W-10E 7.5N-15N | land

- RCA4 (CanESM2)
- RCA4 (CNRM-CM5)
- RCA4 (NorESM1-M)
- RCA4 (EC-EARTH)
- RCA4 (MIROC5)
- RCA4 (HadGEM2-ES)
- ENS. MEAN

Legend:
- hist
- rcp26
- rcp45
- rcp85

Graph showing precipitation trends over time with different models and scenarios.
How do RCP results compare with SRES?

RCA4 ensemble (4 GCMs) Euro-CORDEX

RCA3 ensemble (6 GCMs) Kjellström et al., Tellus 2011
Creating an ensemble of regional climate projections for the Arab Domain
A Strategy According to CORDEX

Develop a matrix of RCD (regional climate downscaling) simulations that employ:

- **Multiple GCMs** as boundary conditions (BCs)
- **Multiple RCMs** driven by a given GCM over a given domain
- **More than 1** representative greenhouse gas emissions scenario
- **With common RCM domains** and resolution
- **With common RCM output** variables and frequency
<table>
<thead>
<tr>
<th>RCM (Institute)</th>
<th>GCM</th>
<th>Historical 1950-2005</th>
<th>RCP8.5 2006-2100</th>
<th>RCP4.5 2006-2100</th>
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<td>EC-Earth 50km</td>
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<td>MPI-ESM 50km</td>
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✔ Completed  ✔ Running  ✔ Planned  ☑ Maybe?